Digital Engineering Benefits Study

Sponsor: OUSD(R&E)

Presented to
INCOSE MBSE Workshop, January 26, 2020
**Tom McDermott**

www.sercuarc.org

- 2018: SERC Project RT-182 conceptually modeled the 5 goals of the DoD DE Strategy to identify necessary acquisition enterprise changes
  Full report: https://sercuarc.org/publication/?id=197&pub-type=Technical-Report&publication=SERC-2018-TR-109-Enterprise+System-of-Systems+Model+for+Digital-Thread+Enabled+Acquisition
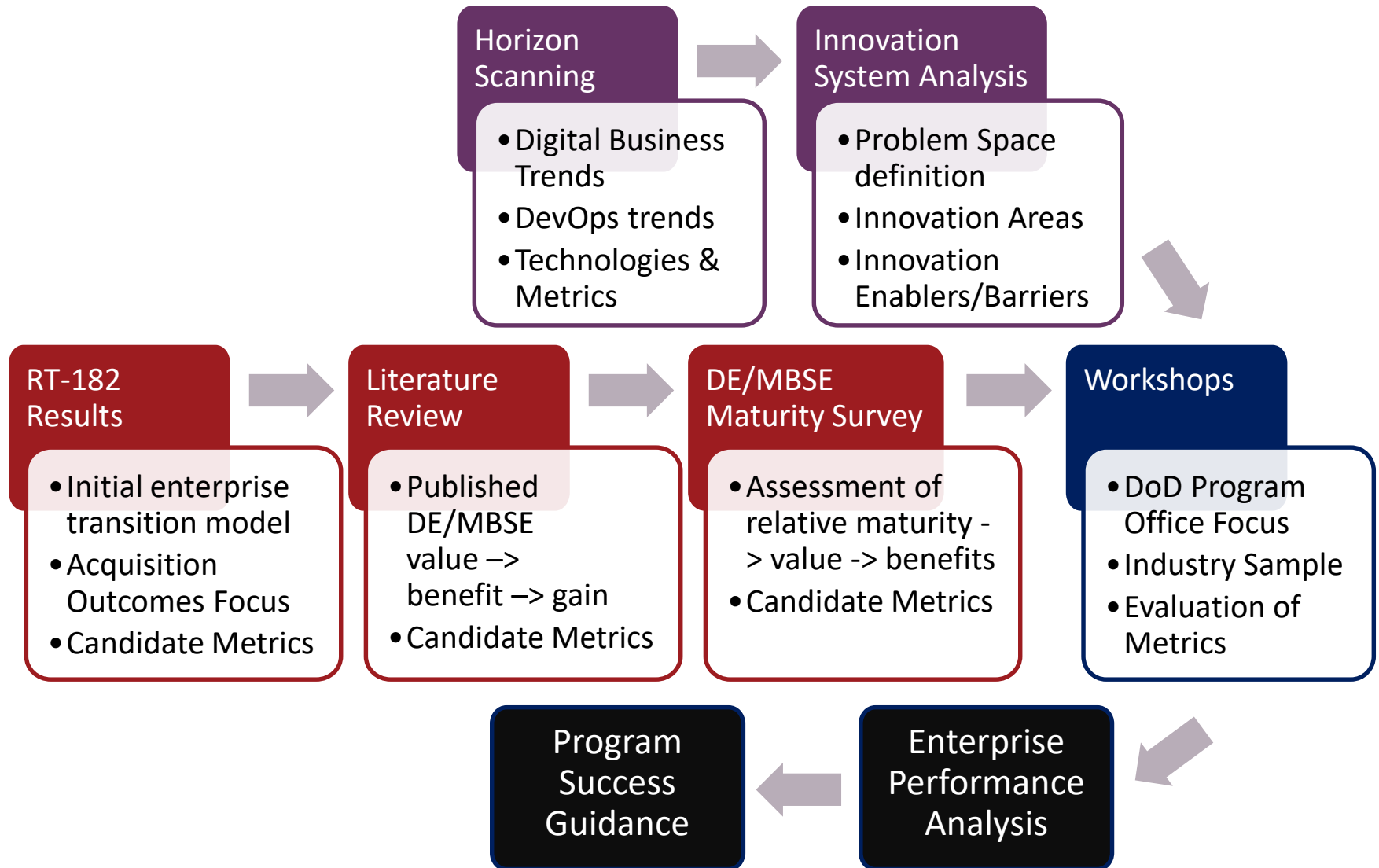
- 2019: Addressing multiple OUSD/RE research priorities:

  —DE Metrics (WRT-1001), determine critical ROI measures and improved SE value indicators

  —Model Curation (WRT-1009), curation practices, enablers, and technical innovation opportunities

  —DE Workforce (WRT-1006), DE competency model for DAU
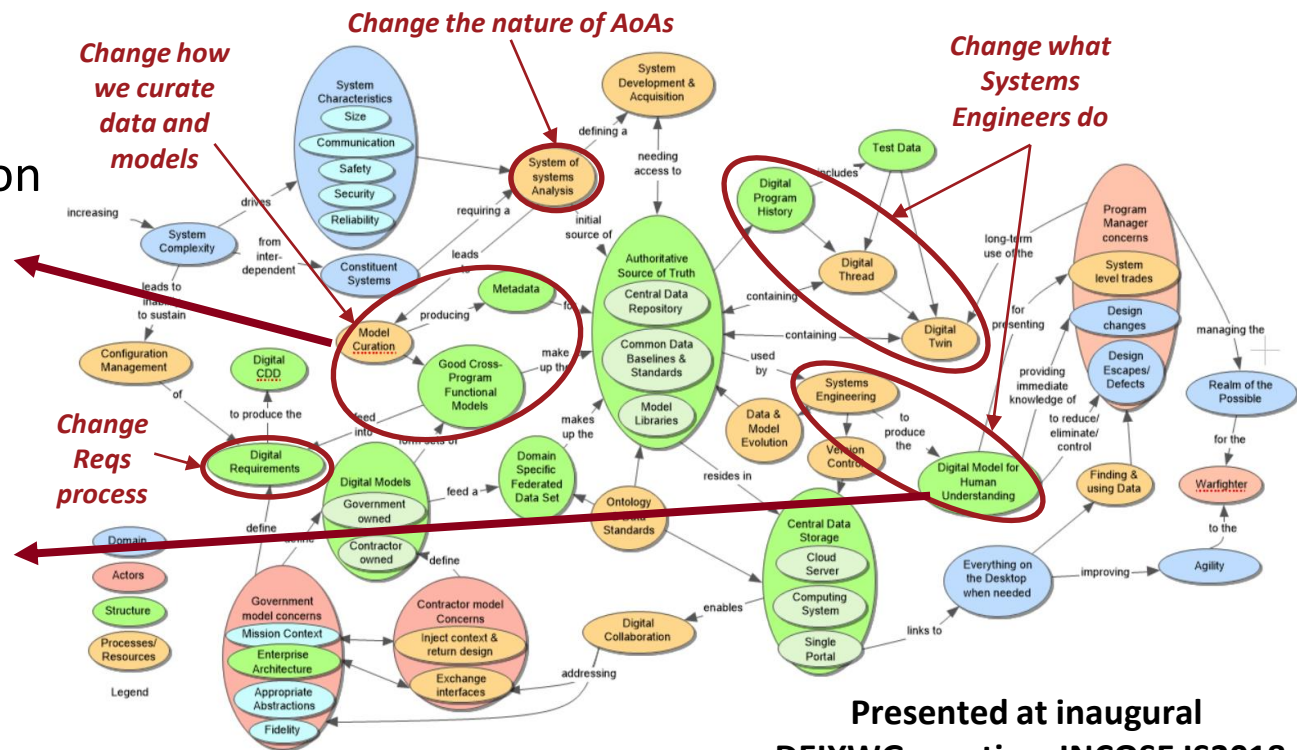
Presented at inaugural DEIXWG meeting, INCOSE IS2018

- If you had a "**Program Office Guide to Successful DE Transition**" what would that look like?

  —Extend previous SERC work on DE enterprise transformation to the program office level.

- How can the **value and effectiveness** of DE be described and measured?

  —Determine appropriate metrics for evaluating the benefits of DE transformation.

- Are there **game-changing methods and/or technologies** that would make a difference?

  —Analyze the DE Innovation System (methods, processes, and tools) to identify gaps and challenges and potential paths for innovation.

- Can we describe an **organizational performance model** for DE transformation?

  —Generalize the data and results.

SERC WRT-1001 DE Metrics Project Activities

Horizon Scanning
- Digital Business Trends
- DevOps trends
- Technologies & Metrics

Innovation System Analysis
- Problem Space definition
- Innovation Areas
- Innovation Enablers/Barriers

RT-182 Results
- Initial enterprise transition model
- Acquisition Outcomes Focus
- Candidate Metrics

Literature Review
- Published DE/MBSE value –> benefit –> gain
- Candidate Metrics

DE/MBSE Maturity Survey
- Assessment of relative maturity -> value -> benefits
- Candidate Metrics

Workshops
- DoD Program Office Focus
- Industry Sample
- Evaluation of Metrics

Enterprise Performance Analysis

Program Success Guidance

Categorizing DE Success Measures

Models are used to inform enterprise and program decision making

An enduring, authoritative source of truth is used over the lifecycle

Use technological innovation to improve engineering practices

Infrastructure and environments support improved communication and collaboration

Transform culture and workforce engineering across the lifecycle

Quality:
- Defects/Design Escapes
- AoA coverage
- Design space explored
- SE rigor
- CM

Knowledge Transfer:
- Data/Model reuse
- Link to Mission Eng
- Depth of review
- Expanded Visualization
- Innovation

Velocity/Agility:
- Data/model reuse
- Decision times
- Cycle time/Agility
- Data search time
- Standards

User Experience:
- Collaboration
- Automation
- Interoperability

Adoption:
- Pace of adoption
- Infrastructure investment
- Enterprise process & tool integration
- Tool/model interoperability
- Role/Skill transition

Preliminary Literature Review Results

- Searched papers that mention a benefit of MBSE and what the source of that benefit was: measured gains, observed gains, perceived gains (no source for benefit), reference.
  - Total Papers that mention MBSE: 847
    - Papers that mention benefits: 360
      - Measured gains: **2**
      - Observed gains: **36**
      - Perceived gains: **240**
      - Reference: 108
      - Misc.: 4

*Kaitlin Henderson (VT) PhD studies

Preliminary Literature Review Results

Category	Perceived	Observed	Measured
Quality	Reduce Errors (16)	Reduce Errors (26)	Reduce Errors (2)
	Traceability (61)	Traceability (9)	Traceability (1)
	> System Quality (21)	> System Quality (0)	> System Quality (1)
	Reduce Risk (22)	Reduce Risk (2)	Reduce Risk (1)
	Rigor (6)	Rigor (1)	Rigor (1)
	Reduce Cost (33)	Reduce Cost (4)	Reduce Cost (0)
Velocity/ Agility	Consistency (44)	Consistency (6)	Consistency (1)
	Reuse (37)	Reuse (5)	Reuse (1)
	Reduce Time (24)	Reduce Time (8)	Reduce Time (1)
User Experience	Automation (5)	Automation (0)	Automation (2)
	< SE Task Burden (4)	< SE Task Burden (0)	< SE Task Burden (1)
	Manage Complexity (48)	Manage Complexity (2)	Manage Complexity (0)
	System Understanding (24)	System Understanding (2)	System Understanding (0)
Knowledge Transfer	Information Access (27)	Information Access (5)	Information Access (2)
	Knowledge Capture (13)	Knowledge Capture (0)	Knowledge Capture (2)
	Architecture (4)	Architecture (0)	Architecture (1)
Adoption	Comm/Info Sharing (68)	Comm/Info Sharing (11)	Comm/Info Sharing (0)
	Integration/V&V (11)	Integration/V&V (3)	Integration/V&V (1)

MBSE Benchmarking Survey

Objective	• Assess **value and effectiveness** of MBSE adoption for improving business outcomes (gov't, industry) – benefits vs. traditional methods. Develop a profile of MBSE use and meeting expectations across the life cycle. • Where are we as organizations, and as an industry? Building models, or <u>**using**</u> models? Applying what we learn. • Enable adopters to conduct a qualitative or quantitative assessment of their progress against MBSE best practices and guidance on developing an improvement roadmap
Method	• Conduct an industry survey of MBSE capability. Align with **INCOSE draft DE Capabilities Definition matrix.** • **Characterizing MBSE practices, capability, value, benefits**. • Probe alignment and integration with other adopter initiatives (e.g., PLM, DevOps, cross-discipline) • Collect and share best practices and assets on MBSE benefits/value from community
Organizational Involvement	• Participation call through industry associations: INCOSE (lead), NDIA, … • Government sponsorship and support: DoD (OUSD R&E), FFRDCs (SERC) • Survey administration by DoD SERC (Stevens Institute) - "honest broker" to protect proprietary data.
Schedule	• **Survey: Closes February 1, 2020**
Core Team	• INCOSE: Garry Roedler; Troy Peterson • NDIA: M&S Committee (Chris Schreiber); SE Division (Joe Elm, Geoff Draper; Garry Roedler) • SERC: Tom McDermott, Nicole Hutchinson

MBSE Survey Overview

Topics	Summary of Survey Questions	Topics	Summary of Survey Questions
1. MBSE Usage	1. MBSE strategy documented at enterprise level 2. MBSE processes & tools integrated, inform enterprise staff *3. Q: Primary value of cross-functional MBSE integration?*	**7. Model Sharing and Reuse**	19. Teams establish, share, reuse org model libraries 20. Org interface around models for stakeholder use 21. Shared models used to consistently manage programs across lifecycle *22. Q: org implementation for data/model discovery, reuse?*
2. Model Management	4. Taxonomy for modeling across organization 5. Well-defined processes/tools for model management. 6. Standard org guidance for model management/tools *7. Q: Business value from consistent model management?*	**8. Modeling Environments**	23. Modeling environment security 24. Modeling environment protects IP 25. Cross-discipline processes for tools, data interoperability *26. Q: value from collaborating on models across disciplines*
3. Technical Management	8. Modeling basis for enterprise org processes 9. MBSE process support for technical reviews *10. Q: Value of MBSE (or digital engrg) in technical reviews?*	**9. Organizational Implementation**	*27. Q: most challenging org obstacles for MBSE?* *28. Q: Best organizational enablers for MBSE?* *29. Q: Biggest changes our org needs forMBSE?*
4. Metrics	11. Modeling provides measurable improvement across projects 12. Consistent metrics across programs/enterprise? *13. Q: Most useful metrics?*	**10. Workforce**	30. Organization defined critical roles to support MBSE *31. Q: Top MBSE roles in your organization?* 32. Org staffing adequate to fill MBSE-related roles?
5. Model Quality	14. Defined processes/tools for V&V of models 15. Defined processes/tools for data/model quality assurance	**11. MBSE Skills**	33. Defined critical skills for MBSE *34. Q: The most critical skills for MBSE?*
6. Data Management	16. Org approach for data interface between tools 17. Data managed independent of tools for portability *18. Q: Data management roles/processes?*	**12. Demographics**	Organizational size, domain, MBSE experience

Survey content is derived from the draft INCOSE Digital Engineering Capabilities Definition

mbsematuritysurvey.sercuarc.org

Survey data as of January 22, 2020.
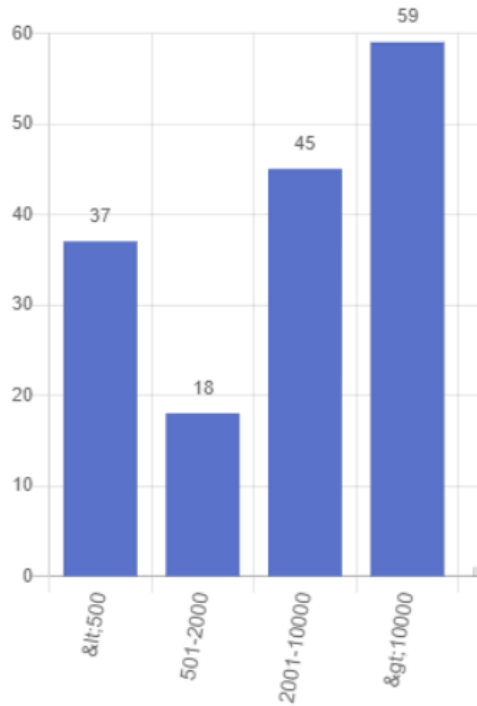Survey will close on February 1.

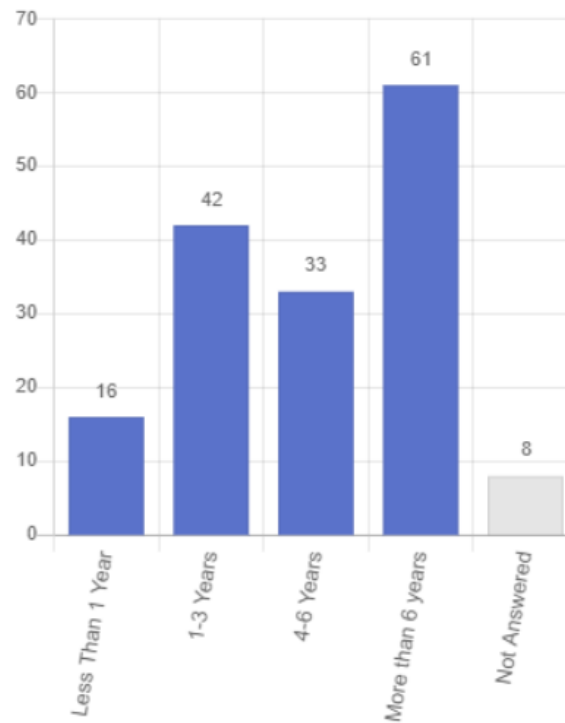# Interim Results: Demographics

My organization is in
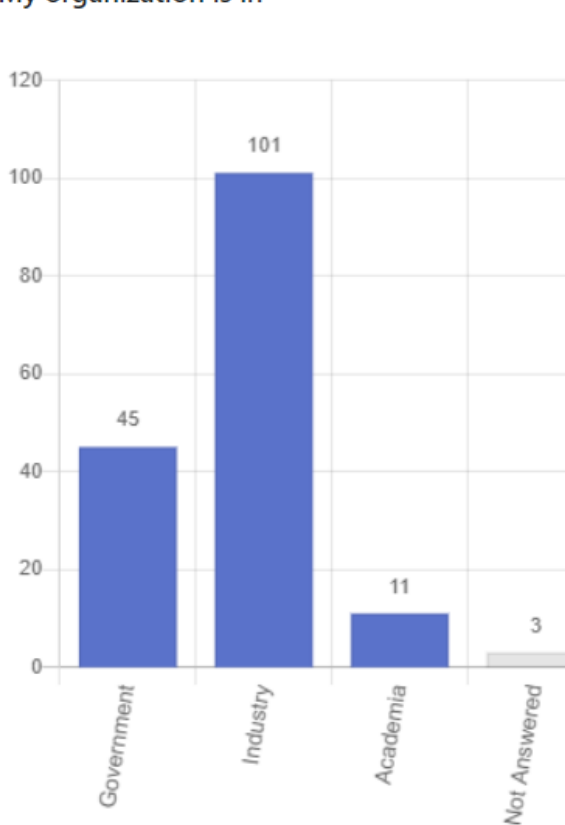
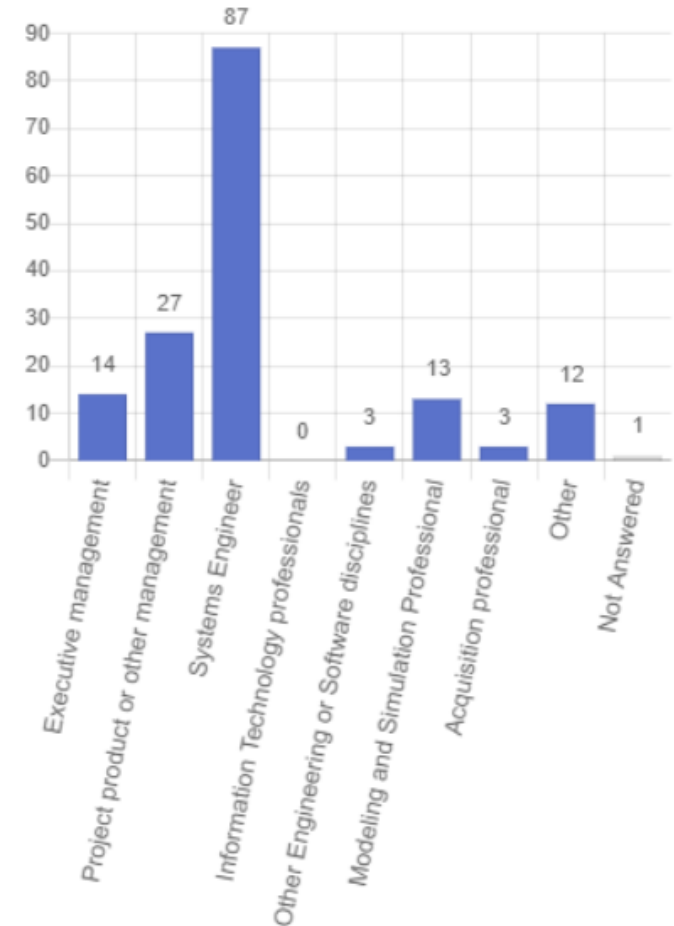# Interim Results: Demographics

Organization Size:

How long has your organization been working toward MBSE:
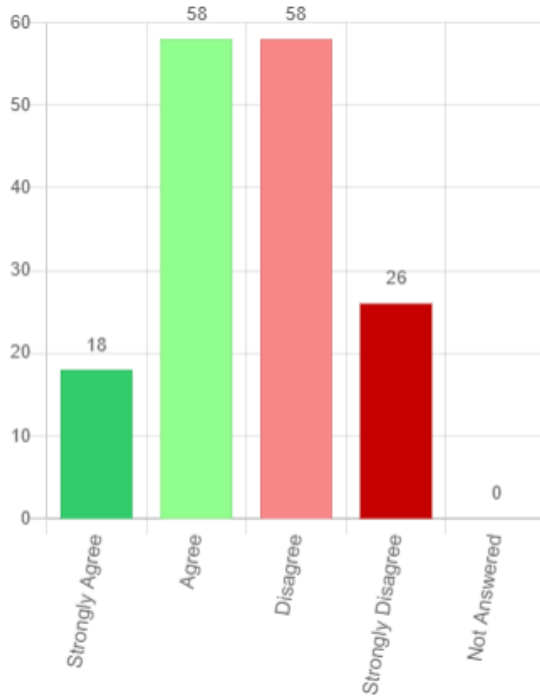
My primary role in my organization is

Interim Results: MBSE Usage

MBSE USAGE

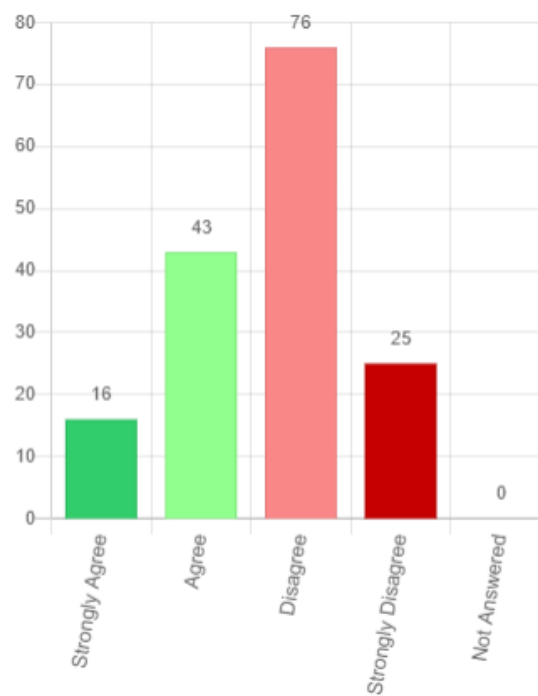Our MBSE use strategy is integrated with our overall product strategy or strategies at the enterprise level.

Agree rate: 2.425

MBSE USAGE

Our MBSE processes and tools are integrated with our overall product-level processes and tools.

Agree rate: 2.312

MBSE USAGE

What do you see as the most important reasons for integrating MBSE processes with program and business management processes?

Answered: 159

Not Answered: 68
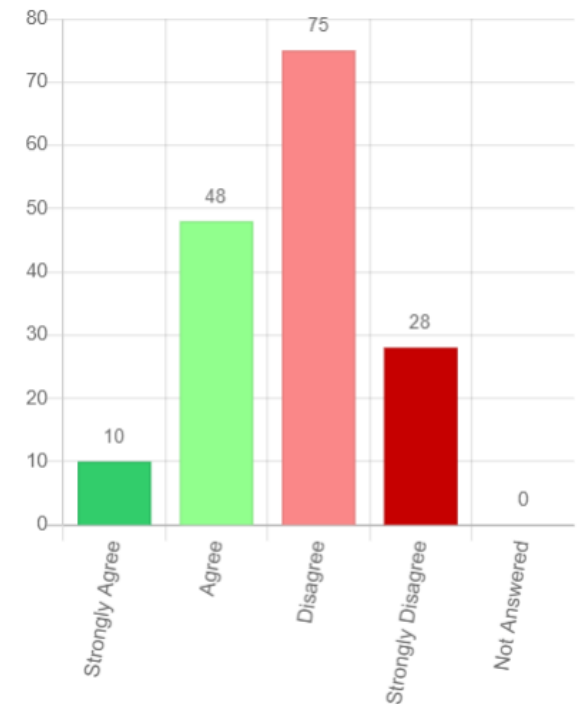
Interim Results: Model Management

MODEL MANAGEMENT

Please provide one or more descriptions of the business value you are realizing from consistent model management processes and tools.

MODEL MANAGEMENT

As part of our MBSE process, we have a clear taxonomy that we use consistently for modeling across our organization.

Agree rate: 2.258
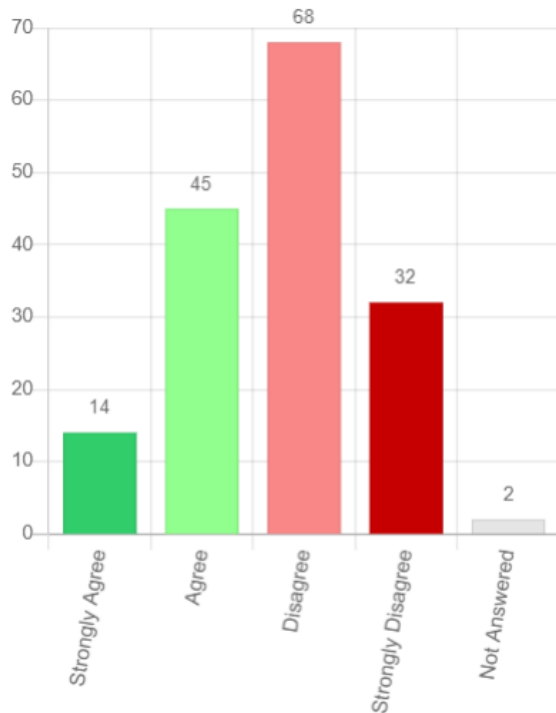
MODEL MANAGEMENT

Our organization has well-defined processes and tools for managing models across a program lifecycle.

Agree rate: 2.226

MODEL MANAGEMENT

Our organization has standard business and program guidance that defines our model management processes and tools.

Agree rate: 2.248

Interim Results: Technical Management

TECHNICAL MANAGEMENT

Our organization uses modeling as the basis for our technical processes consistently across the enterprise.
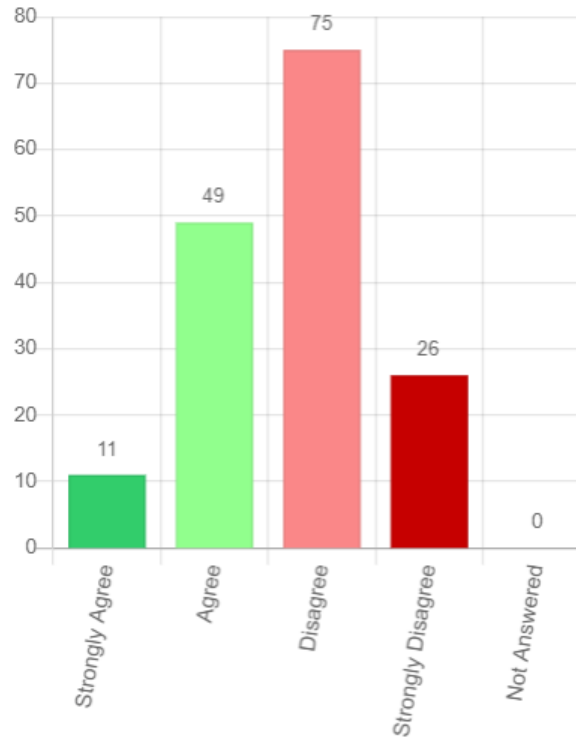
Agree rate: 2.165
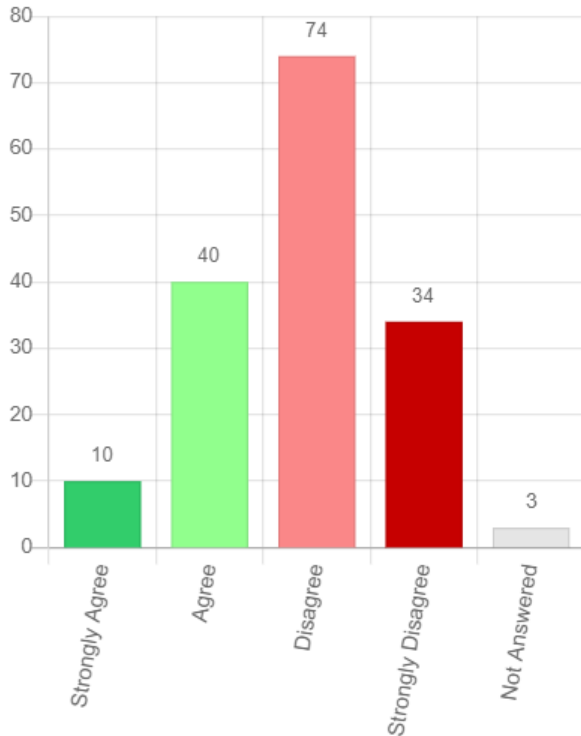
TECHNICAL MANAGEMENT

Our MBSE process fully supports our technical review process.

Agree rate: 2.28

TECHNICAL MANAGEMENT

Please identify any benefits or challenges your organization has found in the use of MBSE (or 'digital engineering') in the technical review process.
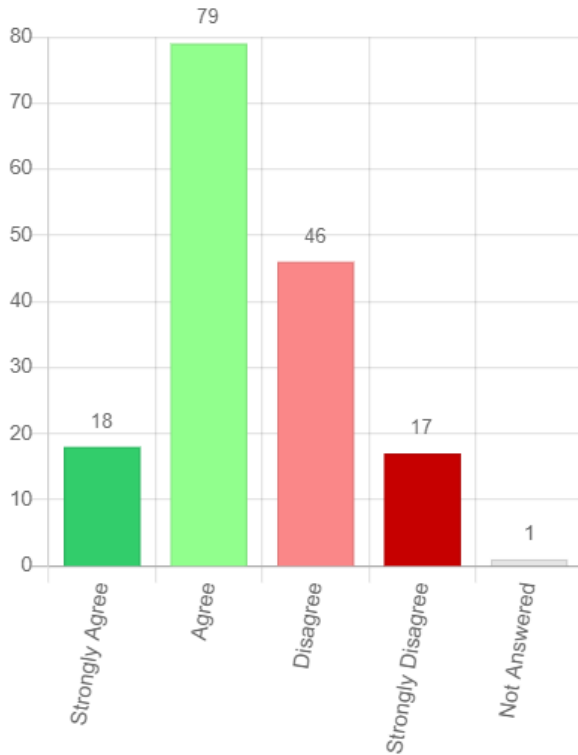
Answered: 111

Interim Results: Metrics

METRICS

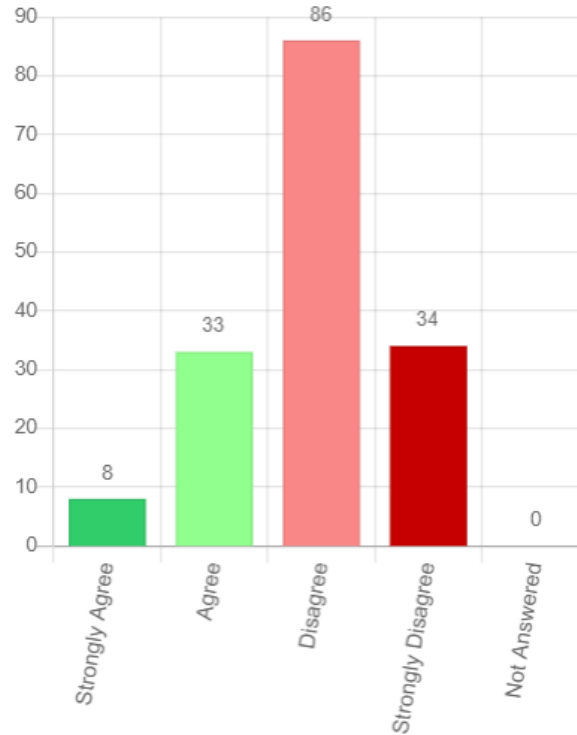**Modeling activities in our organization provide measurable improvements within and across projects.**

Agree rate: 2.612

METRICS

We have consistent metrics across our program(s)/enterprise that include our modeling activities.

Agree rate: 2.093

METRICS

Please identify any metrics that have proven to be useful for measuring the performance of your MBSE activities.
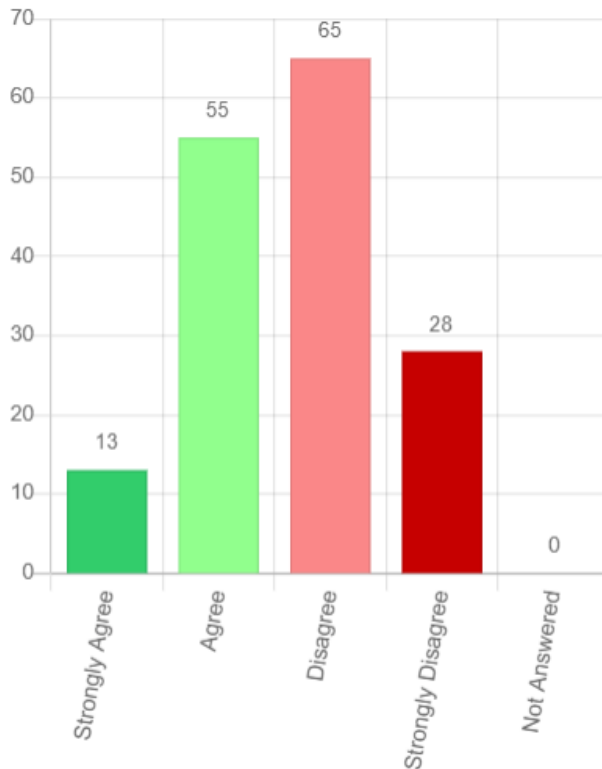
Answered: 92

Interim Results: Model Quality

MODEL QUALITY

Our organization has defined processes and
tools for verification and validation of models at
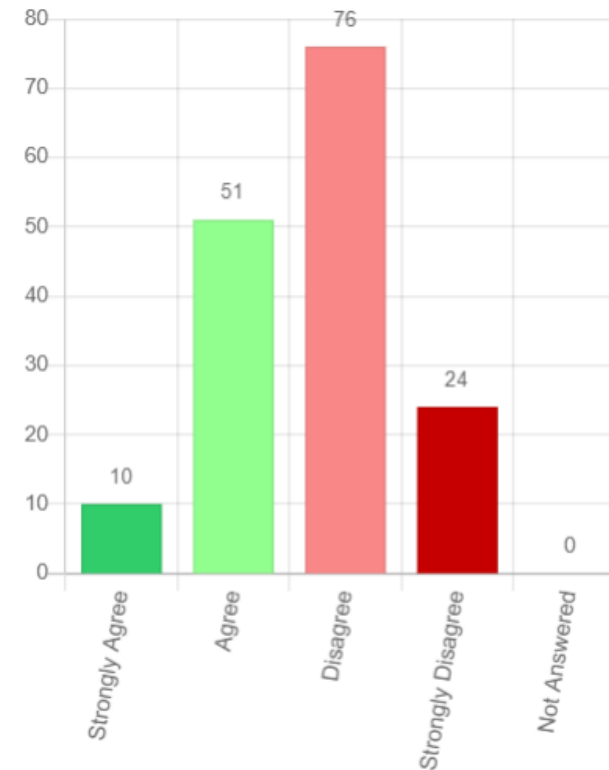appropriate levels and program phases.

Agree rate: 2.329

MODEL QUALITY

Our organization has defined processes and
tools for data and model quality assurance.
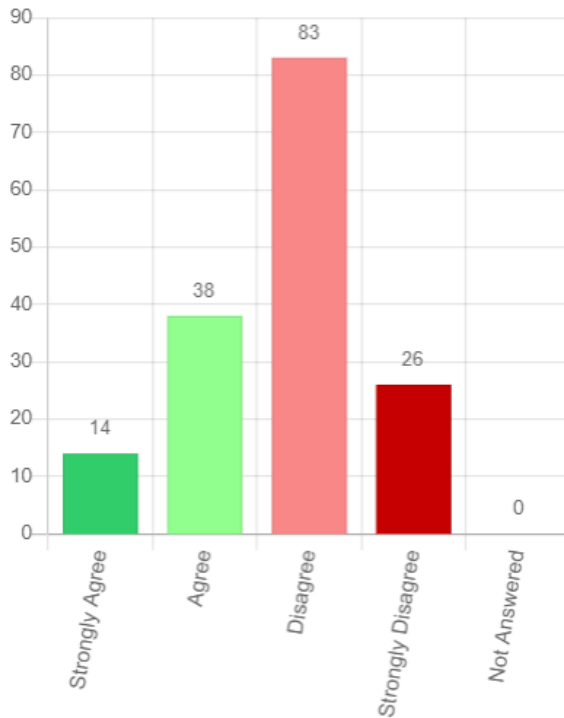
Agree rate: 2.292

Interim Results: Data Management

DATA MANAGEMENT

Our organization has effective approaches for managing the data interface between tools.
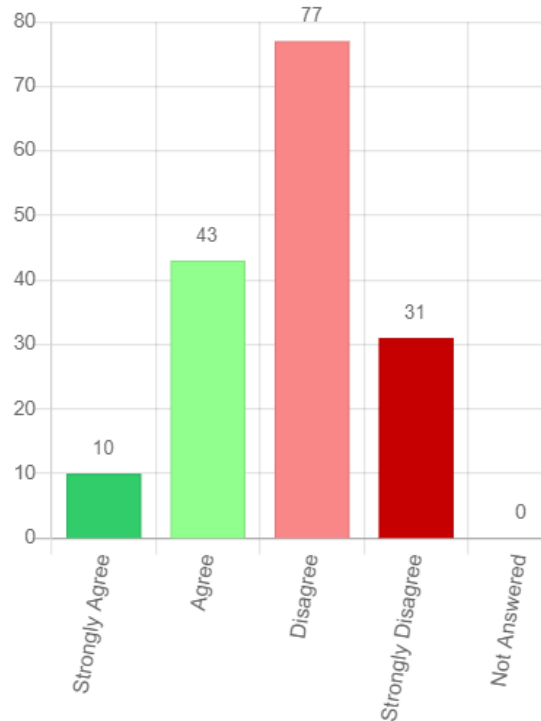
Agree rate: 2.248

DATA MANAGEMENT

Data is managed independent of tools and allows for portability across different organizational structures and related disciplines.

Agree rate: 2.199

New data management roles & processes:

- Chief data and analytics role
- Program Data & Information Architects
- Digital Environment working group
- Data analytics group
- Enterprise tool integration
- IT data store management
- Special database
- V&V of the data
- Stewardship of the data, curator
- TBD but clear it must be architected
- Tool interoperability is an issue
- Need common intermediate data formats
- Concern about data lifecycles
- Industry standards are limiting

Interim Results: Model Sharing & Reuse

MODEL SHARING AND REUSE

Please identify any practices your organization has implemented to improve data and model discovery and reuse, either within or between teams. Include examples of appropriate model reuse if possible.

MODEL SHARING AND REUSE

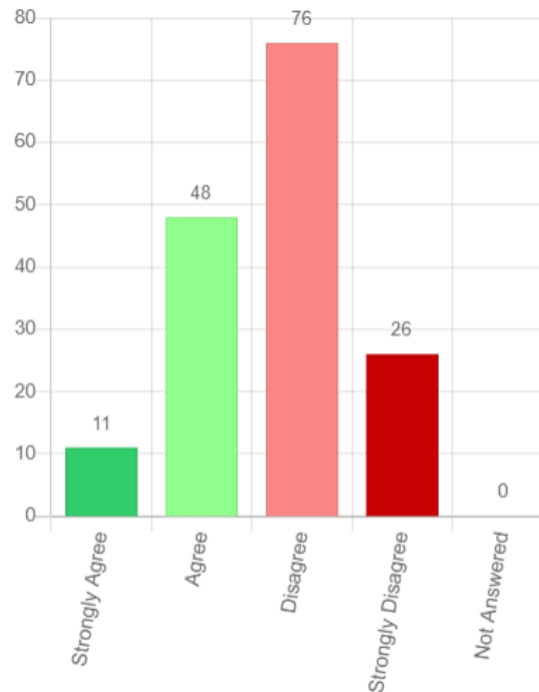Our organization supports model libraries for the purpose of model reuse.

Agree rate: 2.544
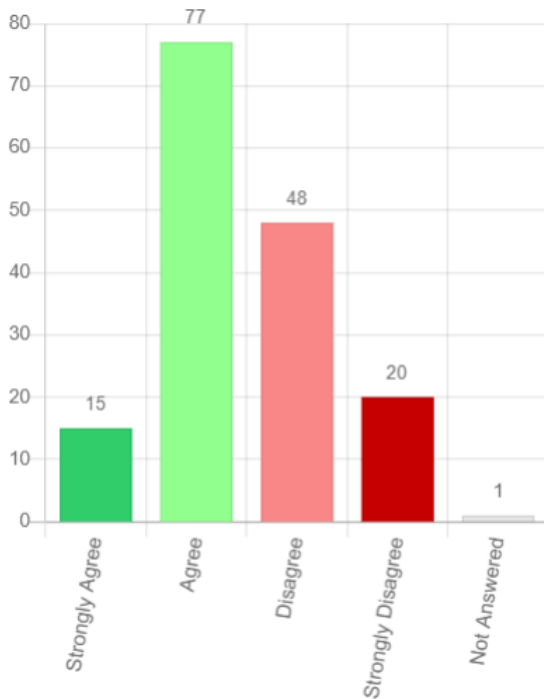
MODEL SHARING AND REUSE

Our organization has implemented an interface around our models that can be used and understood by a variety of stakeholders.
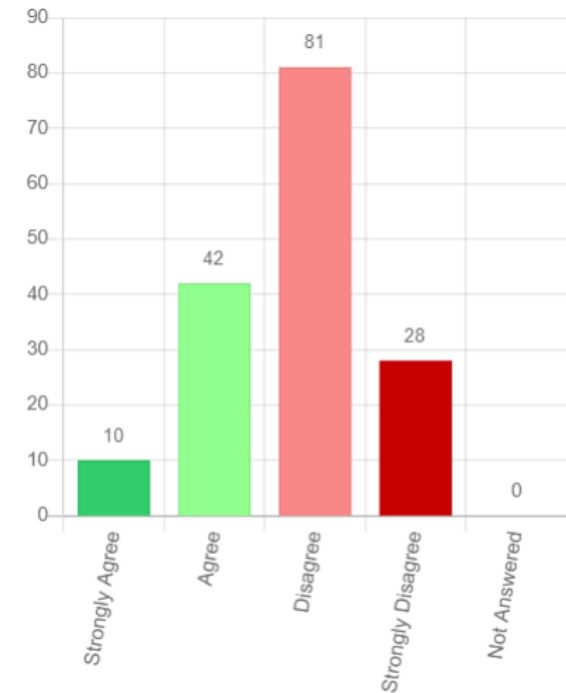
Agree rate: 2.273

MODEL SHARING AND REUSE

Shared models are being used to consistently manage systems across the lifecycle.
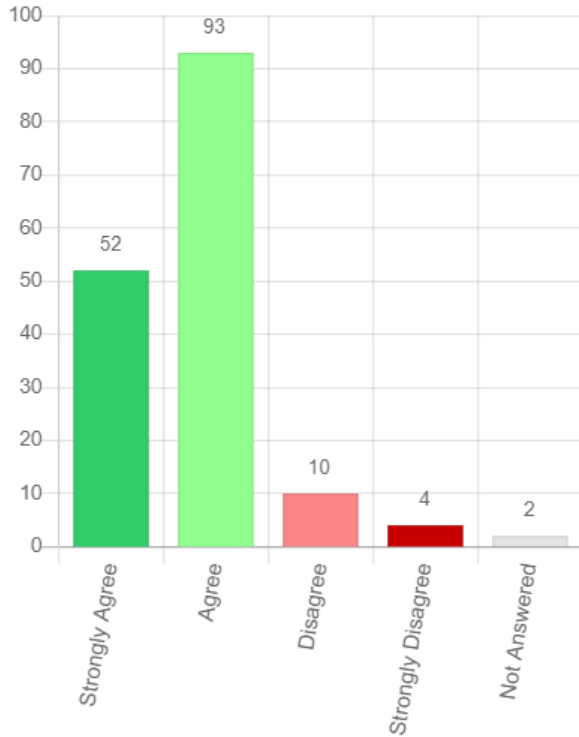
Agree rate: 2.211

Interim Results: Modeling Environment

MODELING ENVIRONMENT

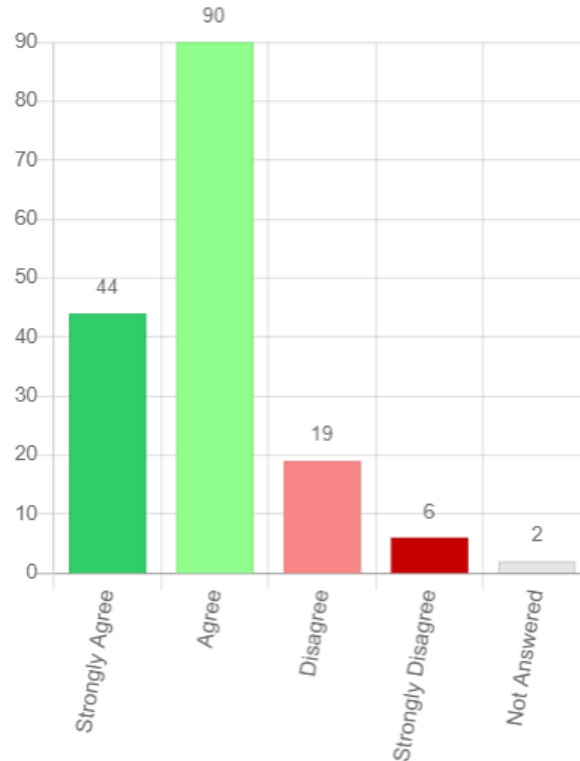Our organization takes steps to make sure our modeling environment is secure.

Agree rate: 3.214

MODELING ENVIRONMENT

Our organization takes steps to make sure that our modeling environment protects our intellectual property.
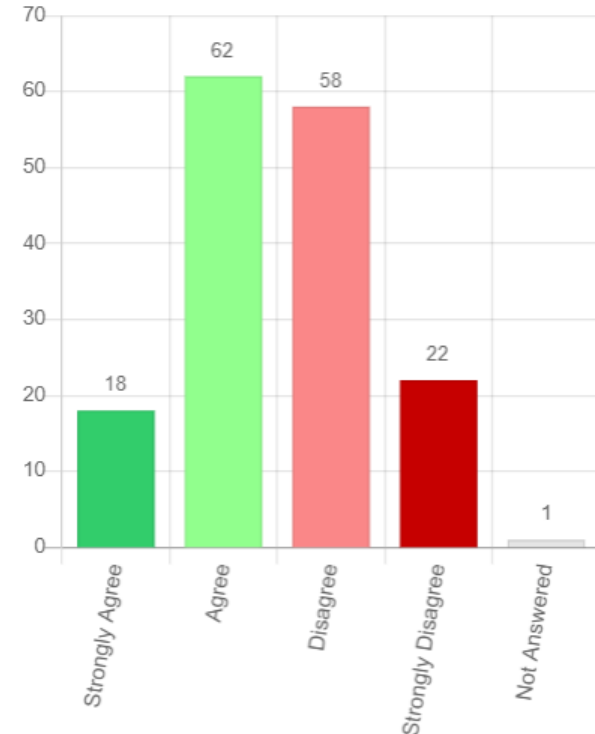
Agree rate: 3.082

MODELING ENVIRONMENT

Our organization has defined processes and work instructions that cover tool selection, use, and related data interoperability concerns.

Agree rate: 2.475

Interim Results: Obstacles & Enablers

MODELING ENVIRONMENT

Please identify any additional benefits you find from collaborating on models across disciplines.

Answered: 79

ORGANIZATIONAL IMPLEMENTATION

The best enablers to MBSE in our organization are:

Answered: 149

ORGANIZATIONAL IMPLEMENTATION

The most challenging obstacles to implementing MBSE in our organization are:

Answered: 158

ORGANIZATIONAL IMPLEMENTATION

Going forward, the biggest changes our organization needs to make to improve our implementation of MBSE are:
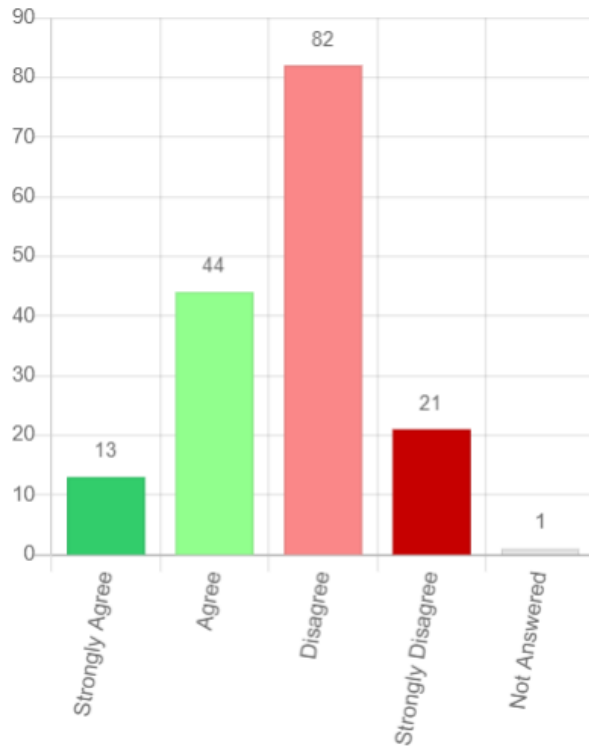
Answered: 144

Interim Results: Workforce

WORKFORCE

Our organization has clearly defined the critical roles to support MBSE.
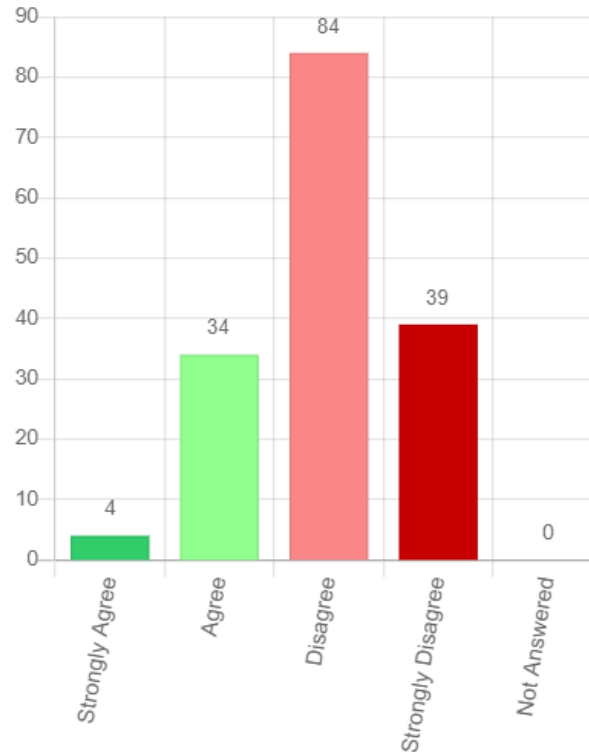
Agree rate: 2.306

WORKFORCE

We have sufficient staffing in our organization to fill all MBSE-related roles.

Agree rate: 2.019

The top MBSE roles in my organization are:
- CTO/Leadership
- Enterprise level SE/DE/Arch Lead
- MBSE group
- Architect, Chief Architect
- Chief Systems Engineer
- Modeling Lead
- Project Manager
- Software Manager
- Engineer/Systems Engineer
- Modeler
- Data Architect
- Project Methodologist
- Tool Expert
- Pattern Architect
- Project Model Librarian/Curator
- Requirements Manager
- Configuration Manager
- Reviewer
- Lead analyst
- Quality
- Trainers/Mentors
- All
- None/poorly defined

Interim Results: Workforce

MBSE SKILLS

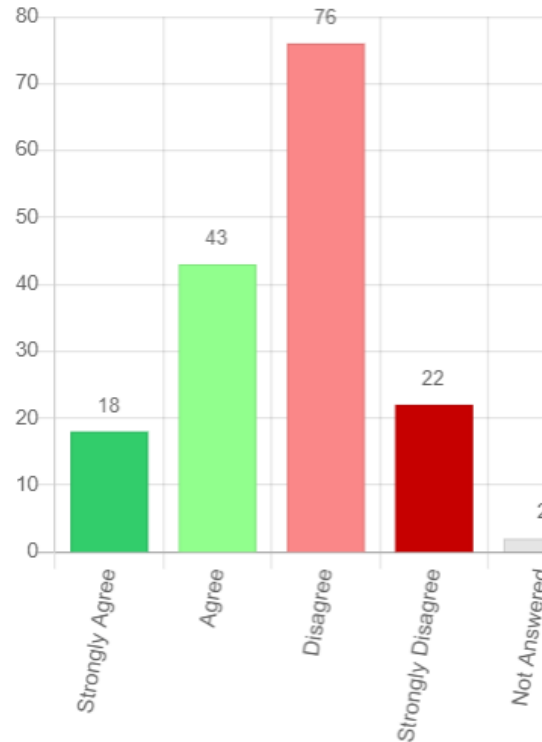Our MBSE training is linked to the critical skill identified for MBSE.

Agree rate: 2.444
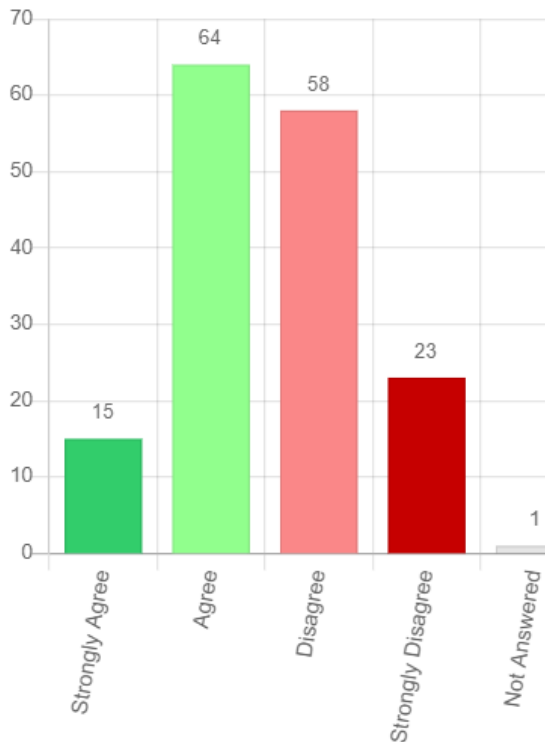
MBSE SKILLS

Our organization has clearly defined critical skills for MBSE.

Agree rate: 2.358

The most critical skills for MBSE are:
- Knowledge of systems engineering processes
- Understanding of systems architecture
- Business architecting, architecture frameworks
- Domain knowledge
- Knowing SysML and operation of modeling tools
- Process management & development
- MBSE "super users"
- Combined SE/MBSE expertise
- Operational modeling
- Informed program management
- Information architecture
- IT/server/cloud management & support
- Requirements Management & tracing
- Report generation
- Collaborative mindset
- Systems & critical thinking
- Analytical thinking/parametric modeling
- Software/programming skills
- Data scientist
- Ontologies
- Customer communication
- Experience
- Interdisciplinarity

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Program Success Guidance

Enterprise Performance Analysis

- The Baldrige Criteria for Performance Excellence (CPE) provide a comprehensive framework of *organizational sub-systems*

- Used for recognition (the national Baldrige Award), assessment & diagnosis of organizational and process maturity, and to guide large-scale transformation (e.g., to pay attention to all key sub-systems during transformation)

http://www.nist.gov/baldrige

For example:
- Leaders communicate clear reason for MBSE adoption
- MBSE aligned with overall organizational strategy
- Workforce have needed skills to support MBSE use
- Data management processes support MBSE
- Organizational culture aligned with MBSE use
- Clear metrics defined to track results and progress
- MBSE adoption aligned with what customers need

Questions?

Thank you!